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SANITIZED VERSION OF PRELIMINARY STUDY OF THE VENTILATION SYSTEM
(Sanitized Version of CRD Document # CKC-3)

Compiled by
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Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

September 12, 1995

Oak Ridge K-25 Site
Oak Ridge, Tennessee 37831-7314
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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
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ADC or ADD signature (Name of person) Date 15 Sep 95

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PRELIMINARY STUDY OF THE VENTILATION SYSTEM

RESTRICTED DATA
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Introduction

A. The purpose of this study is threefold:

1. To obtain information which will result in more efficient operation of the present system.

2. To compare the actual performance of the system with the design performance.

3. To obtain data on which to base changes in the design of the present system.

B. Bldgs. 302-2, 3, and 4 of section 2a were chosen as the site of the study as these buildings contain 10 cells each and should prove as difficult to ventilate as any buildings which are on stream at present.

C. In as much as maximum design outside temperatures of 95-100° F. were not encountered during this test, it was found necessary to predict the performance from data gathered at somewhat lower temperatures.

Summary

A. The ventilating system substantially meets, or exceeds, design conditions regarding the amount of air delivered to the various sections of the buildings. One exception is the amount delivered over the tops of cell enclosures. With all the ducts throughout the system wide open, this flow was found to be 20 per cent less than design. This can be corrected by throttling the ducts which discharge to the withdrawal alleys, since 35 per cent over design flow is discharged into the withdrawal alleys.

B. Temperatures in the withdrawal alleys can be maintained at, or below, the design maximum of 110° F. even with an outside temperature of 95 to 100° F. Air to the withdrawal alleys should be throttled as much as possible to provide a maximum air flow to the motor alleys. Temperatures in the motor alleys will run close to design maximum (120°) on hot days (95 to 100°F) at converter tails temperature but can be somewhat lowered by operating with converter tails temperature At present, the motor alley temperatures average about 20°F. above the outside at a tails temperature of

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C. The operating floor temperatures average about 5-7° above outside temperatures on warm days (80-85°F.). With proper operation of the present system, operating floor temperature should not exceed 10°F. above outside temperatures as a maximum. Some reduction in this differential can be obtained by redesigning the fresh air distributing system so as to direct the fresh air down towards the floor at a distance of at least 15 to 20 ft. from the ceiling louvres which discharge the operating floor air to the roof. The present distributing system has the following objectionable features:

1. Air circulation is principally at ceiling level, since the ducts discharge at the ceiling and parallel to it.

2. Circulation is partially short-circuited due to the proximity of the discharge louvres to the supply ducts.

3. Temperatures near the floor are as high, or higher, than the temperature of the air leaving the operating floor through the discharge louvres, indicating incomplete mixing of fresh air with air lying close to the floor.

D. The article, "Operating Instructions for 300 Section Ventilating System" does not require amendment as a result of this test. If followed, it will permit the ventilating system to function at maximum efficiency.

E. The heating of the air as it passes through the basement to the fan suction will be vertually eliminated at temperatures of 90°F. or above, if proper operation is employed. No air should be permitted to reach the basement from other parts of the building during hot weather operation.

F. The heating of the air to the operating floor as it passes in ducts up through the cell floor averages about 2°F, with a maximum of 4°, at present. It is estimated that, on warm summer days, this heating will be negligible.

Procedure

A. All temperature measurements were secured with standard mercury thermometers having ranges of 0-120°F., calibrated to 1°F., and read to the nearest ½°. In all cases, the thermometers were given ample time to reach equilibrium with the surroundings.

B. Air velocity data in the high range, (above 2,500 ft. per minute), were obtained by pitot traverses, and the flows were calculated with an A.S.H.V.E. accepted formula. Velocities in the lower range were measured directly using an "Alnor Velometer" (Illinois Testing Laboratory). For extremely small velocities, as were encountered during the operating floor circulation study, a Taylor Anemometer was used.

Humidity readings were secured with a standard wet and dry bulb thermometer.

C. The tests were conducted in all cases, except where otherwise noted, with the system set for maximum air throughput and no recycling (i.e. maximum cooling conditions).

Discussion of Data

A. Table I

The design data were obtained from the operating manual, "Building and Building Utilities", Volume IX, section on Ventilation. It should be borne in mind that these data were based on a cell enclosure temperature the ambient Actually, at a tails temperature air in the enclosure was found to be about 140°F.

The data of this report were taken at a tails temperature except where otherwise noted. Insofar as outside temperatures did not reach design during the test, the only criteria for comparison of performance with design are temperature rises from the outside to various places in the building. Design calls for a 5°F. rise to the operating floor, 10°F. rise to the withdrawal alley and 20°F. rise to the motor alley.

B. Table II

This table presents the maximum flow of air obtainable at each type of outlet with all blowers on and all ducts wide open. From this table, the following conclusions are drawn:

1. Flow to the operating floor is 10 percent less than design. However, this is within the limit of error of the measurements.

2. Flow per cell to the motor alley exceeds the design flow by 10 percent.

3. Flow per cell to the withdrawal alley exceeds the design flow by about 35 percent.

4. Flow per cell over the tops of the cell enclosures is 20 percent less than design.

The above conclusions indicate that too much air will be delivered to the withdrawal alley and an insufficient amount to the ducts over the cell enclosures if all the ducts are opened wide. Otherwise, the flows in the system appear to meet design within the limit of error of measurement. It is therefore necessary to restrict the flows to the withdrawal alleys to provide a higher system pressure. A higher system pressure will increase the flows over the tops of the cell enclosures.

C. Table III, Table IV and Figure 1

A study of the increase in the temperature of the air as it passes through the basement to the fans is presented. Table III contains the detail readings. Table IV presents the averages of the temperature differences from filter to innermost fan suction, and the corresponding outside temperature. Figure 1 is a plot of the data of Table IV. From Figure 1, it is concluded that at outside temperatures of 90-95°F., the temperature difference will be negligible, or, in other words, at outside temperatures of 90-95°F., air will reach the innermost fans at virtually outside temperature. It is understood that this conclusion is based on sealing the basement from the rest of the building, which is required during hot weather operation.

D. Table V

The data collected during the study of the ventilation of the operating floor under maximum ventilating conditions are presented in Table V. The following conclusions are drawn from these data regarding the ventilating system of Bldg. 302-4, or other buildings having the same type of ventilators.

1. Less air is required in the rear of the building than in the middle and front portions.

2. The difference between the temperature of the fresh air coming to the operating floor and the temperature of the air leaving the floor varies between 0 to 4.5° F. and averages about 3°F. There are no local hot spots.

3. The greatest heat "pickup" is obtained near the center and front portions of the floor. These regions have the highest prevailing temperatures.

4. The operating floor air temperatures (dry bulb temperatures) approximate the temperatures of the air leaving the floor through the roof ventilators. However, in a great many cases, places on the operating floor are slightly higher in temperature than the air leaving. This condition indicates that:

   a. There is insufficient mixing of incoming air and air on the operating floor (0-8 ft. off the floor). This is probably because fresh air is directed along the ceiling at ceiling level and does not drop to the floor.

   b. The ventilating air is short-circuited somewhat, (i.e. fresh air reaches the discharge ventilators before mixing with air on the floor).

   c. There is virtually no temperature gradient from the floor to the roof. This means that the roof ventilators do not take off a layer of warmer air lying nearer the roof. Furthermore, the fresh cooler air, because it is admitted near the ceiling, mixes with rising warm air and apparently does not drop toward the floor since there is no density difference.

   d. Humidity is evenly distributed over the operating floor and apparently air traveling the length of the basement and up to the front of the building does not increase in humidity over air sent directly up from the filter end of the basement.

In addition to the above conclusions based on data in Table V, additional conclusions were drawn from a study of the air currents made on the operating floor with an anemometer. No concrete data could be obtained, but it was evident from placing the anemometer in various positions on the floor, between the floor and the roof, and close to the roof, that the type of supply duct, whose discharge is at the center of the floor and close to the ceiling, has the following characteristics:

1. It will throw air along the ceiling across the building for a distance of 20-25 ft. in two distinct paths.

   a. Along the I-beam which lies close to every ventilator.

   b. At an angle of about 30° to the I-beam.

2. A portion of the air discharged by each ventilator blows directly across the roof louvre where warm air is supposed to discharge. This results in the afore-mentioned short-circuiting, and in addition, partially "blankets" the louvre from receiving the warm air it is intended to discharge.

E. Table VI

The data presented in Table VI can be compared with the design data on the basis of the temperature rises found between the outside air and the air at various points in the building under various operating settings. In addition, the effect of lowering the converter tails temperatures is brought out.

1. By comparing the data for April 3, 4 and 5 with design data, it is apparent that air temperatures can easily be held below the maximums specified for outside temperatures from 49° to 75°F. and at converter tails temperatures

2. At an outside temperature of 75°F., the maximum temperature in the motor alley was 108°F. ΔT therefore equals 33°F. when the difference between outside air and the cell enclosures
   At 100°F., outside temperature, the temperature difference, ΔT, between the outside air and motor alley maximum would be:

or Motor alley maximum temperature = 120.3°F.

This result indicates that the motor alley temperatures will closely approximate the design value of 120° F. This method of prediction is based on the assumption that, at constant cooling medium throughput, the amount of heat transmitted to the cooling medium is proportional to the temperature difference between the cooling medium and object being cooled.

3. A comparison of the data and conditions of April 4 with those of April 13, indicates that decreasing the tails temperature reduced the temperature difference between the outside air and the motor alley from 33° to 19°F. This temperature difference is well within the design limits and will be even smaller as the outside temperature increases above the test conditions of 84°F, outside temperatures.

4. The withdrawal alley temperatures are nearly the same as the operating floor temperatures. Since they were expected to run 5° hotter, and since the operating floor temperatures will approximate design, it can be seen that the withdrawal alley will undoubtedly run cooler than design. Thus, air flow to the withdrawal alley can be reduced below the design value.

F. Table VII

The data presented in Table VII compares the temperature of the air entering the fans at the basement with the temperature of the same air arriving at the operating floor. It is seen that the rise in temperature of the air as it passes in ducts up through the cell floor is limited to a maximum of 4°F. and averages about 2°. The rise is somewhat greater in the ducts located in the center and front end of the building than in the rear, as would be expected.

Since from Figure I it is apparent that, at outside temperatures above 90°F., there will be practically no rise in temperature as air passes through the basement, it is apparent from Table VII that air will discharge to the operating floor about 2-4°F. above outside temperatures, on hot days.

Since the difference between the temperature of the air entering the operating floor and the temperature of the air already on the floor averages about 3°F., as shown in Table V, it can be seen that the operating floor will average 5-7°F. above outside temperature at a converter tails temperature

TABLE 1

DESIGN DATA

SECTION 2A

Operating Floor System:

Atmospheric Air Temperature	95°F.
Atmospheric Humidity	70% relative
Air Flow per Fan	23,000 c.f.m.
Total Air Flow	115,000 c.f.m.
Pressure Rise over Fans	1.17" H_2O
Operating Floor Temperature	100°F.

Cell Floor System:

Atmospheric Air Temperature	100°F.
Atmospheric Humidity	70% relative
Air Flow per Fan	24,000 c.f.m.
Total Air Flow	240,000 c.f.m.
Pressure Rise over Fan	3.3" H_2O
Air to Motor Alley	7,000 c.f.m. per cell
Air to Withdrawal Alley	11,000 c.f.m. per cell
Air to Top of Cell	6,000 c.f.m. per cell
Motor Alley Air Temperature*	120°F. maximum
Withdrawal Alley Air Temperature*	110°F. maximum

*Based on cell enclosure temperature of

TABLE 11

AIR FLOW DATA

BLDG. 302-4 - MAXIMUM FLOW

A. Operating Floor System:

Fresh Air Outlets:

Average Velocity	1200 feet$_2$ per minute
Effective Area	4.3 feet^3
Flow per Outlet	5150 feet^3 per minute
Total Flow	103,000 feet^3 per minute

Operating Conditions:

(1) All 5 Fans Operating

(2) Pressure Rise over Fans = 1.18" H_2O

(3) All Duct Dampers Open

(4) Average Air Temperature = 78°F.

B. Cell Floor System:

Motor Alley Floor Registers:*

Average Velocity from 0.80 feet^2 Duct 3210 feet per minute
Average Velocity from 0.40 feet^2 Duct 3630 feet per minute

Maximum Flow per Duct:	
0.80 feet^2 Duct	2,570 c.f.m.
0.40 feet^2 Duct	1,450 c.f.m.
Total Flow to Motor Alley	77,500 c.f.m.
Flow to Motor Alley per Cell	7,750 c.f.m.

TABLE II (cont'd)

Withdrawal Alley Louvres:*	
Average Velocity for All Louvres	2,770 feet per minute
Flow from 1.87 feet^2 Louvres	5,180 c.f.m.
Flow from 0.90 feet^2 Louvres	2,520 c.f.m.
Total Flow to Each Alley per Building	76,600 c.f.m.
Total Flow to Each Alley	153,400 c.f.m.
Flow to Withdrawal Alley per Cell	15,340 c.f.m.
Flow over Cell Tops (by difference)	
Flow per Cell	4,870 c.f.m.
Total Flow	48,700 c.f.m.
Maximum Total Flow to Cell Floor:**	
Total to Cell Floor	278,000 c.f.m.
Total per Cell Row	139,000 c.f.m.

* Determined by Impact Pressure
** Estimated from Fan Characteristic Curve Furnished by Manufacturer.

TABLE III

BASEMENT AIR TEMPERATURES

Time	Position	Recorded 4/5/45 K-302-2	K-302-3	K-302-4	Recorded 4/14/45 K-302-2	K-302-3	K-302-4
9:00 AM	Filter				71°F	71°F	72°F
	Cell 9				74	75.5	72.5
	3				--	73	--
	1				82	80.5	83
10:00AM	Filter	47.5°F	46°F	47°F	74.5	75	74.5
	Cell 9	48.5	46.5	48	76	73	74.5
	3	55	57	58	78	79	77.5
	1	75	76	73	82	84	84
11:00AM	Filter	48.5	49	50.5	80	79.5	79.5
	Cell 9	49	49	51	80	79	78
	3	56.5	59	58.5	81.5	80.5	81
	1	74	75	72.5	84.0	86.5	85
12:00 N	Filter	50.5	49	49	80.5	79.5	80
	Cell 9	51.5	49	58.5	80.5	79	79
	3	57.5	57.5	50	82	81	82
	1	73.5	72.5	49	85.5	86.5	87.5
1:00 PM	Filter	50	49.5	53	81.5	87.5	81
	Cell 9	51	50	54	81.5	87.5	80.5
	3	58.5	60	60.5	83	82	83
	1	75.5	75.5	--	85	82	--
2:00 PM	Filter	51.5	50.5	53	63.5	87.5	82
	Cell 9	53	51.5	54	83.5	87.5	82
	3	59	60.5	61	84	85	83
	1	74	74.5	74	86	86.5	84
3:00 PM	Filter	51	51	52	83	82	83
	Cell 9	53	52	54	84	82	83
	3	59	62	61	84	85	84
	1	74.5	74	74	86	88	86
4:00 PM	Filter	52	52	53.5	82	82	82.5
	Cell 9	53.5	53.5	55	82.5	82	82.5
	3	59	59	62	83.5	83.5	84
	1	74.5	74	76	85	89	85

NOTE: All temperatures except at filter were taken at blower suction of blower beneath respective cell.

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G.L.E.
4/18/45

TABLE IV

AVERAGE BASEMENT TEMPERATURES

(From Table III)

Outside Temperatures °F.	Front Fan Temp. °F.	Δ T °F.
47°	75°	28°
49	74	25
49.5	73.5	24
51	74	23
51	74	23
52.5	74.5	22
71.5	82	10.5
74.5	83.5	9
80	86.5	6.5
81	84.5	3.5
82.5	86.5	4.0
82	86.5	3.5

TABLE V

OPERATING FLOOR DATA

(BLDG. 302-4)

	Time 10:00 AM	11:00	1:00 PM	2:00	3:00	4:00
Air Supply -°F						
Cell 1	84.5	85.5	88	88	89	89
3	81	83	86	86.5	87	86
9	75.5	79.5	82.5	83	84	84
Air Out -°F						
Cell 1	85.5	86.5	89.5	90.5	91.5	92
3	84.5	86	88.5	90	91	91.5
9	79	80	83	84.5	86	85.5
Dry Bulb - Wet Bulb -°F						
Cell 1	85.5-72	86-71	90-73	90-78	92-76	92-77
3	85-71.5	86.5-72	90-73	91.5-76	92-76	93-74
9	80-70	82-70	85-73	88-74	89-75	89-73
Relative Humidity (%)						
Cell 1	53	48	45	58	48	51
3	53	50	45	48	48	41
9	60	55	57	52	53	48
Absolute Humidity-gr.per # drain						
Cell 1	88	92	94	126*	110	116
3	87	94	94	110	110	96
9	87	90	102	104	109	96

* Discarded as in error.

Test Conditions:

1. System set for maximum removal of heat (i.e. maximum air flow - no recycling.
2. A sunny day (4/14).
3. Dry bulb - wet bulb temperatures taken on the operating floor near panel boards of cells, 5 feet from floor.
4. Converter tails temperature

CKC-3
G.H.B.
4/18/45

Table VI

AIR TEMPERATURES AT VARIOUS POINTS

IN VARIOUS BUILDINGS

	4/3	4/4	4/5	4/13
Converter Tails Temperature	67	75	49	84
Outside Air Temperature	109	108	96	105
Motor Alley Maximum	86.5	89	78	94
Withdrawal Alley Maximum	86	89	81	94
Operating Floor Maximum				

Conditions of Tests:

4/3 Partial recycling from cell floor to basement. Operating floor 100 percent flow - no recycling.

4/4 No recycling - cell and operating fllor set for maximum flow.

4/5 Partial recycling on cell and operating floor.

4/13 No recycling - cell and operating floor set for maximum flow.

Table VII

AIR SUPPLY TO OPERATING FLOOR 302-4*

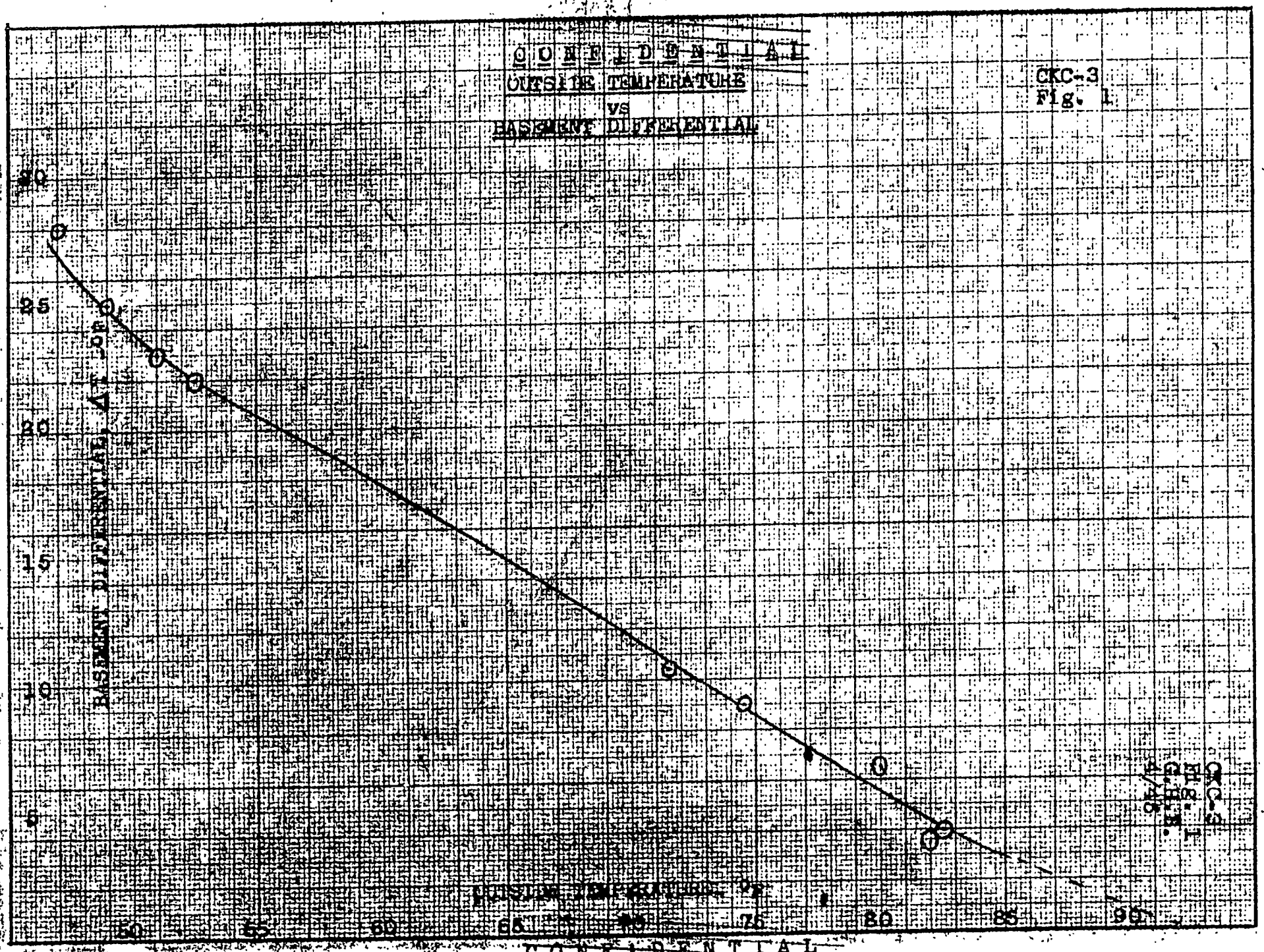
(From Table III and V)

	Time					
	10:00 AM	11:00	1:00 PM	2:00	3:00	4:00
Cell 1						
Fan Suction	84°F	85°F	88°F	84°F	86°F	85°F
Op. Floor Discharge	84.5	85.5	88	88	89	89
Cell 3						
Fan Suction	77.5	81	83	83	84	84
Op. Floor Discharge	81	83	86	86.5	87	86
Cell 9						
Fan Suction	74.5	78	80.5	82	83	82.5
Op. Floor Discharge	75.5	79.5	82.5	83	84	84

* Maximum cooling conditions prevailing, converter tails temperature

CKC-3
Fig. 1

OUTSIDE TEMPERATURE
vs
BASEMENT DIFFERENTIAL



CKC-3
Fig. 1

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